Unit 2

Electrical and Electronic Components

Introduction

There are several important electrical components that are commonly found in circuits. These components are the fundamental building blocks of electrical and electronic circuits, and can be found in large numbers in a control panel, printed circuit board, etc. They can be used and combined with each other in different ways to form a new circuit. This Unit will help students to understand the fundamentals of circuit schematics.

An electrical control system includes a number of components, which are assembled together to form a circuit as shown in Fig. 2.1. It is important to understand about the components assembled in the control panel. Each component has its data sheet on which its details are mentioned.

Before assembling an electric circuit, a wireman must have detailed knowledge of the components. The person must be able to distinguish the components physically. There are some common components, which are used in almost every control system, such as resistor, capacitor, integrated circuit, LED, etc. The person must know the characteristics of each component, dependence of each component on different parameters and the basic construction of each component.

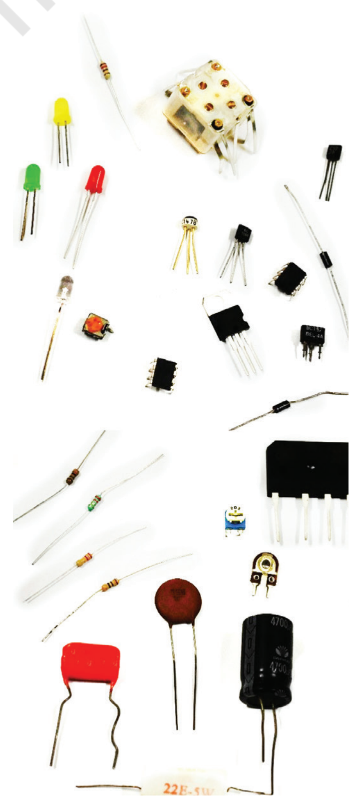

Fig. 2.1 Basic circuit components

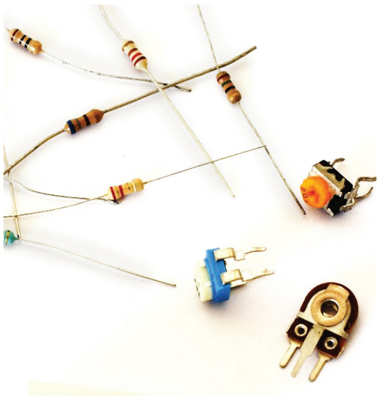

Fig. 2.2 Resistor

Resistor

Resistor is one of the fundamental components in an electrical and electronic device as shown in Fig. 2.2. A resistor opposes the movement of electrons. This opposition is called 'resistance'. The resistor controls the current flow, and also drops the voltage across it, thus, lowering the voltage levels within circuits. It has two ends. High-power resistors are used to dissipate electrical power. Resistors can have fixed resistance value. This fixed resistance value can change slightly when there is a change in temperature, time or operating voltage. Resistors whose value can be changed are called 'variable resistors'. These variable resistors can be used to control different parameters. For example, in a radio circuit, the variable resistor is used as a volume control component. Resistor family can be classified into two types.

1. Linear resistor
2. Non-linear resistor

Linear resistor

In this type of resistor, the value of resistance is directly proportional to the applied voltage. There are two types of linear resistor.

1. Fixed resistor
2. Variable resistor

Fixed resistor

Such a resistor has a fixed resistance value. Fixed resistor family includes carbon composition resistor, film resistor, wire wound resistor and cracked carbon resistor.

Carbon composition resistor

This comprises general purpose resistors, consisting of carbon and silica. Carbon and silica provide the specified resistance between two leads. Carbon composition resistors give a uniform performance and are available in ¼, ½ and 1 watt. The value of resistance is printed in the form of colour code.

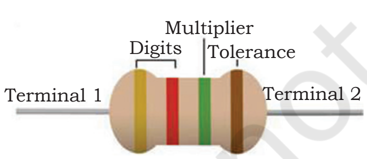

Fig. 2.3(a) Colour-coded resistor

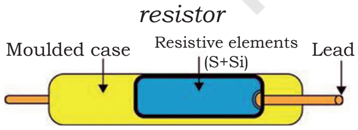

Fig. 2.3(b) Internal structure of carbon composition resistor

Film resistor

Carbon film resistor, metal film resistor and thick film resistor are the three forms of film resistor.

In carbon film resistor, pure carbon is deposited on a ceramic rod by high temperature thermal decomposition. By controlling the thickness of pure carbon, a wide range of resistance value can be produced in a resistor. Such a resistor has better stability than carbon composition resistor.

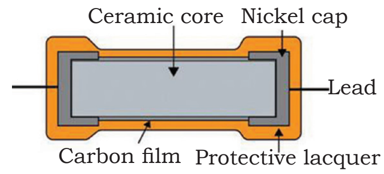

Fig. 2.4 Internal structure of carbon film resistor

In metal film resistor, the glass of ceramic substrate is coated with a thin film of metal or alloy or metal oxide. Such a resistor gives the best reliability and stability. It can handle overload for a short time and is used in electronic equipment.

A thick film resistor is formed by applying a resistive film, mixture of glass and conductive material to a substrate of silicon. Thick film technology is used to produce high resistance value resistors. These values are printed on a cylindrical or flat substrate. The range of resistance value is 1 ohm to 100 kilo-ohm and wattage up to 200 watt.

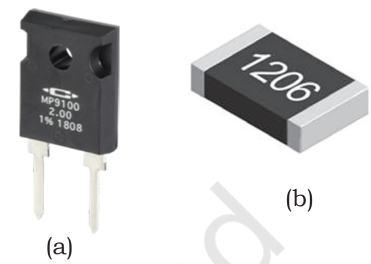

Fig. 2.5(a) Thick film resistor (b) Surface mount thick film resistor

Wire wound resistor

Such a resistor consists of a high resistance wire. This wire is, usually, made of nickel-chromium alloy, which wound on a ceramic core in the resistor. Such resistors can operate in high temperatures. They have high wattage rating. The range of resistance value of these resistors varies from 1 ohm to 100 kilo-ohm and wattage rating up to 200 watt.

Fig. 2.6(a) Wire wound resistor

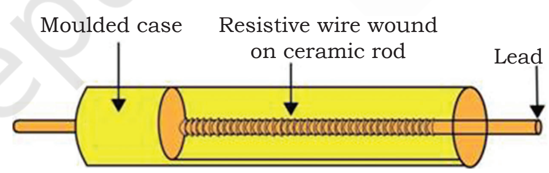

Fig. 2.6(b) Internal structure of a wire wound resistor

Cracked carbon resistor

This type of resistor uses decomposed hydrocarbon vapour on ceramic rod at 900^0 to 1000^0 C. These hydrocarbons provide the required resistance value.

Variable resistor

The resistance value in such a resistor can be changed using a rotating knob. Variable resistor family includes potentiometer and trimmer.

Potentiometer

It is a three-terminal variable resistor. Out of the three terminals, two end terminals are used for input and output, and the centre terminal is used as a variable

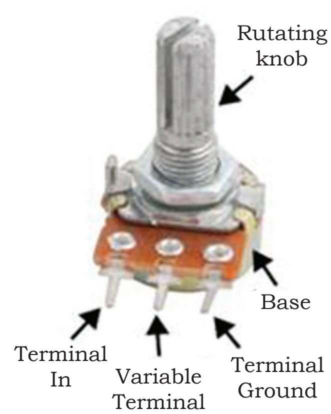

Fig. 2.7(a) Potentiometer

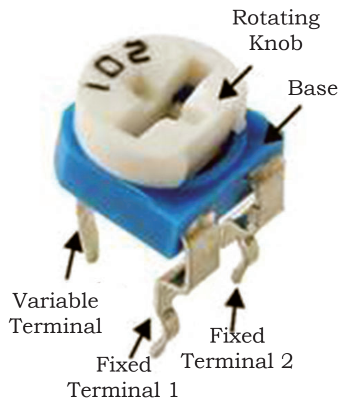

Fig. 2.7 (b) Trimmer

terminal. The resistance value can be changed using a rotating knob. Such a resistor has carbon composition. It is used to control voltage and current in an electric circuit.

Trimmer

It is miniature adjustable resistor composed of a resistive element like carbon or silica. It can be directly mounted on a printed circuit board. Its resistance value can be adjusted using a small screwdriver. Usually, it is mounted on audio-video circuits.

Non-linear resistor

In non-linear resistor, the current is not directly proportional to the applied voltage. Such a resistor has the property to change its resistance value in accordance with the applied voltage, temperature or light intensity. Non-linear resistor family includes thermistor (temperature dependent resistor), varistor (voltage dependent resistor), photoresistor (light dependent resistor). Fig. 2.8 shows the symbolic representation of linear and non-linear resistors.

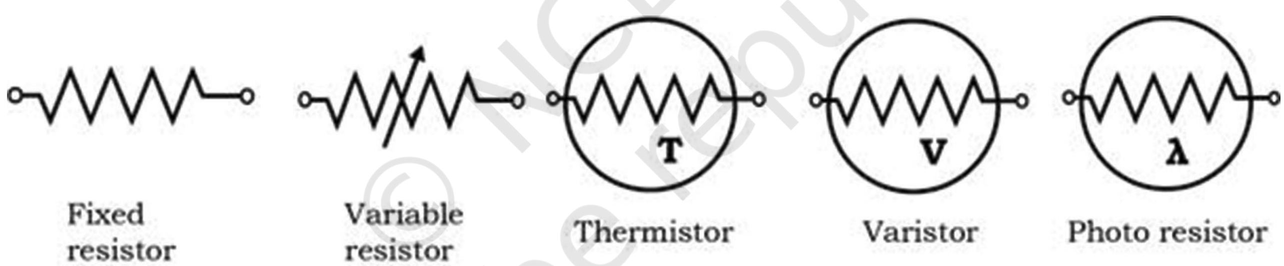

Fig. 2.8 Symbolic representation of linear and non-linear resistors

Thermistor

It is a thermally sensitive resistor, i.e., the resistance changes in accordance with the change in the temperature. There are two types of thermistor.

- Negative temperature coefficient (NTC)
- Positive temperature coefficient (PTC)

In NTC, the resistance decreases exponentially with increase in temperature, whereas, in PTC, the resistance increases with increase in temperature. Typical NTC and PTC are shown in Figs. 2.9(a) and 2.9(b).

Fig. 2.9 (a) Negative temperature coefficient (NTC) thermistor

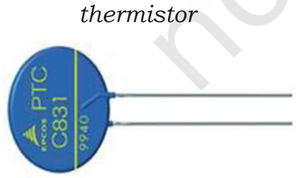

Fig. 2.9 (b) Positive temperature coefficient (PTC) thermistor

Varistor

It is a voltage dependent resistor (VDR). Its resistance value changes in accordance with the applied voltage. It is used to protect a circuit and circuit components. There are two types of voltage dependent resistors, i.e., silicon carbide VDR and metal oxide VDR.

Fig. 2.10 Varistor

Photoresistor

It is a light dependent resistor (LDR). Its resistance value changes in accordance with light illumination. In darkness, the resistance is high and when an LDR gets illuminated, the resistance decreases. The LDR consists of light sensitive semiconductor. The photoconductive material is deposited on the ceramic substrate. LDR is used in automatic light control switches, for automatic brightness control in television sets, streetlights, alarm clocks, burglar alarm circuit, etc.

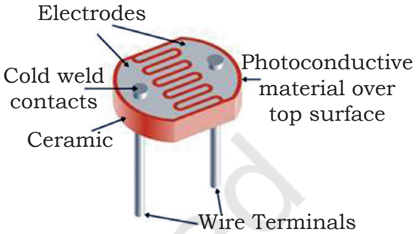

Fig. 2.11 Light dependent resistor (LDR)

Assignment 1

Identify and name the different types of resistor and write their resistance value.

Resistor	Name and resistance value
	Name ____________ Name and resistance value ____________
	Name ____________ Name and resistance value ____________
	Name ____________ Name and resistance value ____________
	Name ____________ Name and resistance value ____________

Fig. 2.12: Series connection of resistors

Series connection of resistors

$R_{equivalent} = R_1 + R_2 + R_3 + \ldots$

Series key idea: Current is the same in each resistor by Kirchhoff's current law (Fig. 2.12).

Features of resistors in series

1. Series resistances add: $R_s = R_1 + R_2 + R_3 + \ldots$
2. The same current flows through each resistor in series.
3. Individual resistors in series do not get the total source voltage but divide it.

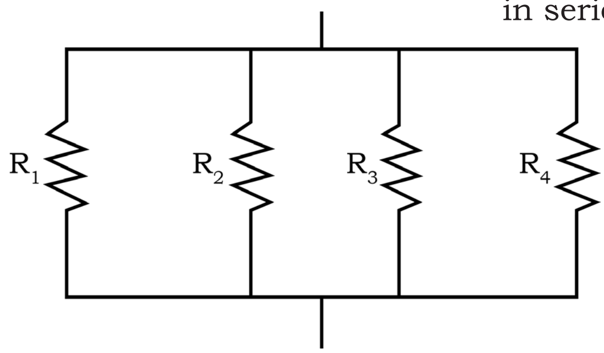

Fig. 2.13: Parallel connection of resistors

Parallel connection of resistors

$1/R_{equivalent} = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$

Parallel key idea: Voltage is the same in each resistor by Kirchhoff's voltage law (Fig. 2.1).

Practical Exercise 1

Demonstrate the way to calculate resistance, current, voltage drop and power dissipation of a series circuit.

Material required

Pen and paper

Procedure

Suppose the voltage output of the battery in Fig. 1 is 12V, and the resistances are R1 = 1Ω, R2 = 6Ω and R3 = 13Ω.

(a) What is the total resistance?

(b) Find out the current.

(c) Calculate the voltage drop in each resistor, if these add up to equal the voltage output of the source.

(d) Calculate the power dissipated by each resistor.

(e) Find out the power output of the source and show that it equals the total power dissipated by the resistors.

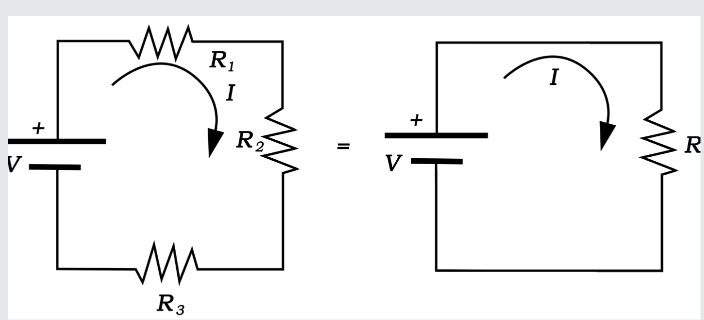

Fig. 1

Solution for (a)

The total resistance is simply the sum of individual resistances as given in this equation:

$$R_s=R_1+R_2+R_3=1\Omega+6\Omega+13\Omega=20\Omega$$

Solution for (b)

The current is found using Ohm's law, V = IR. Entering the value of the applied voltage, the total resistance yields the current for the circuit.

$$I=V \times R_s=12\ V \times 20\Omega=0.6A$$

Solution for (c)

The voltage or IR drop in a resistor is given by Ohm's law. Entering the current and the value of the first resistance yields the following.

$$V_1 = IR_1 = (0.600A)\ (1\ \Omega) = 0.600\ V$$

Similarly,

$$V_2 = IR_2 = (0.600A)\ (6\ \Omega) = 3.60\ V$$

and

$$V_3 = IR_3 = (0.600A)\ (13.0\ \Omega) = 7.80\ V$$

Discussion for (c)

The three IR drops add to 12 V, as predicted:

$$V_1 + V_2 + V_3 = (0.600 + 3.60 + 7.80)\ V = 12\ V$$

Strategy and solution for (d)

The easiest way to calculate power in watt (W) dissipated by a resistor in a DC circuit is to use Joule's law, P= IV, where P is electric power. In this case, each resistor has the same full current flowing through it. By substituting Ohm's law V = IR into Joule's law, we get the power dissipated by the first resistor as

$$P_1 = I^2R_1 = (0.600\ A)2(1.00\ \Omega) = 0.360\ W$$

Similarly,

$$P_2 = I^2R_2 = (0.600\ A)2(6.00\ \Omega) = 2.16\ W$$

and

$$P_3 = I^2R_3 = (0.600\ A)2(13.0\ \Omega) = 4.68\ W.$$

Discussion for (d)

Power can also be calculated using either P= IV or $P=V_2R$, where V is the voltage drop across the resistor (not the full voltage of the source). The same values will be obtained.

Solution for (e)

The easiest way to calculate power output of the source is to use P = IV, where V is the source voltage. This gives

$$P = (0.600\ A)(12.0\ V) = 7.20\ W$$

Discussion for (e)

Note, coincidentally, the total power dissipated by the resistors is also 7.20W, the same as the power generated by the source.

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That is,

$P_1 + P_2 + P_3 = (0.360 + 2.16 + 4.68)\ \text{W} = 7.20\ \text{W}$

Power is energy per unit time (watts), and so conservation of energy requires the power output of the source to be equal to that of the total power dissipated by the resistors.

Practical Exercise 2

Calculating resistance, current, power dissipation and output of a parallel circuit.

Material required

Pen and paper

Procedure

Let the voltage output of the battery and resistances in the parallel connection as in Fig. 1 be the same as previously considered in the series connection: V = 12.0 V, R_1 = 1.00 Ω, R_2 = 6.00 Ω, and R_3 = 13.0 Ω,

(a) What is the total resistance?

(b) Find out the total current.

(c) Calculate the currents in each resistor and show these add up to equal the total current output of the source.

(d) Calculate the power dissipated by each resistor.

(e) Find out the power output of the source and show that it equals the total power dissipated by the resistors.

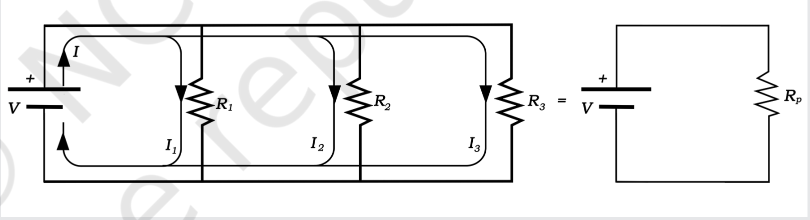

Fig. 1 Parallel circuit

Solution for (a)

The total resistance for a parallel combination of resistors is found using the equation given below. Entering known values gives

$$1/R_p = 1/R_1 + 1/R_2 + 1/R_3 = 1/1.00\ \Omega + 1/6.00\ \Omega + 1/13.0\ \Omega$$

Thus,

$$1/R_p = 1.00\ \Omega + 0.1667\ \Omega + 0.07692\ \Omega = 1.2436\ \Omega$$

(Note that in these calculations, each intermediate answer is shown with an extra digit.) We must invert this to find the total resistance R_p. This will yield

$$R_p = 1/1.2436\ \Omega = 0.8041\ \Omega$$

The total resistance with the correct number of significant digits is R_p = 0.804 Ω

Discussion for (a)

R_p is, as predicted, less than the smallest individual resistance.

Solution for (b)

The total current can be found from Ohm's law, substituting R_p for the total resistance. This gives

$I=V/R_p=12.0\ V/0.8041\ \Omega=14.92\ A$

Discussion for (b)

Current I for each device is much higher than for the same devices connected in series (see the previous example). A circuit with parallel connections has a lower total resistance than the resistors connected in series.

Strategy and solution for (c)

The individual currents are easily calculated from Ohm's law, since each resistor gets the full voltage. Thus,

$I_1=V/R_1=12.0V/1.00\ \Omega=12.0\ A$

Similarly,

$I_2=V/R_2=12.0\ V/6.00\ \Omega=2.00\ A$

and

$I_3=V/R_3=12.0\ V/13.0\ \Omega=0.92\ A$

Discussion for (c)

The total current is the sum of the individual currents.

$I_1 + I_2 + I_3 = 14.92\ A$

This is consistent with conservation of charge.

Strategy and solution for (d)

The power dissipated by each resistor can be found by using any of the equations relating power to current, voltage and resistance, since all three are known. Let us use $P=V^2/R$, since each resistor gets full voltage. Thus,

$P_1=V^2/R_1= (12.0\ V)^2/1.00\ \Omega=144\ W$

Similarly,

$P_2=V^2/R_2= (12.0\ V)^2/6.00\ \Omega=24.0\ W$

and

$P_3=V^2/R_3= (12.0\ V)^2/13.0\ \Omega=11.1\ W$

Discussion for (d)

The power dissipated by each resistor is considerably higher in parallel circuit than when connected in series to the same voltage source.

Strategy and solution for (e)

The total power can be calculated in several ways. Choosing P = IV, and entering the total current, yields

$P = IV = (14.92\ A)\ (12.0\ V) = 179\ W$

Discussion for (e)

Total power dissipated by the resistors is also 179 W.

$P_1 + P_2 + P_3 = 144\ W + 24.0\ W + 11.1\ W = 179\ W$

This is consistent with the law of conservation of energy.

Overall discussion

Note that both the current and power in parallel connections are greater than for the same devices in series.

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There are a number of factors, such as material, thickness, length and temperature, which affect the resistance value of a wire.

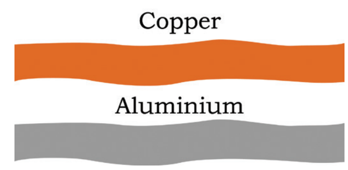


Fig. 2.14 Material used for wire

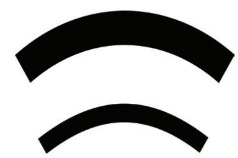


Fig. 2.15 Thickness of wire

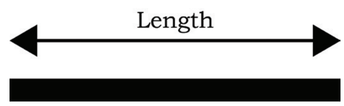


Fig. 2.16 Length of wire

Fig. 2.17 Temperature of wire

Assignment 2

Calculate the value of equivalent resistance in parallel and series circuits, where value of resistors are R_1= 10 and R_2 = 20 Ohm.

Capacitor

The word 'capacitor' specifies capacity. It represents the capacity to store energy. In a capacitor, energy is stored in the form of electric field. Capacitance is measured in Farad (F). A capacitor has two parallel sections. It is between these sections that energy is stored. It consists of two metallic conducting sections (plates) separated by an insulator (dielectric material) as shown in Fig. 2.18. A metallic conductor can be made of aluminium, copper, etc. A dielectric can be ceramic, mica, electrolyte, air, paper, etc. It stores charges on its metallic plates, which generate the electric field between the plates. Hence, it stores energy in the form of electric field.

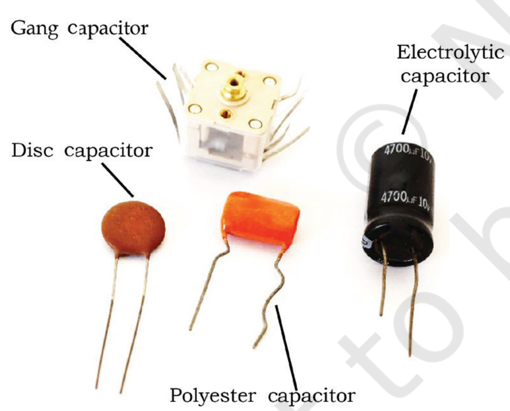


Fig. 2.18 Capacitor

Capacitor is one of the fundamental components of electrical and electronic devices. The parameters of a capacitor are the maximum voltage that it can withstand without damage, charge store capacity, polarity of terminals, i.e., positive and negative terminals as shown in Fig. 2.19.

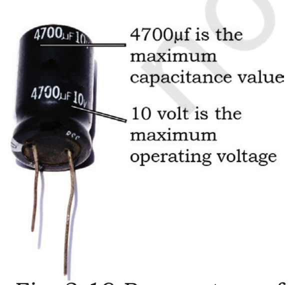


Fig. 2.19 Parameters of a capacitor

Mathematically,

$Q = C \times V$

where, Q= Charge in coulomb

C= Capacitance in farad

V= Voltage in volt

For example: When 250V is applied across the capacitor of capacitance value 10μF, the amount of charge stored by it is given by

$Q = C \times V$

$Q = 10 \times 10^{-6} \times 250$

$Q = 2.5$ mC

Assignment 3

Calculate the following for a capacitor.

1. Determine the voltage across a 1000 pF capacitor to charge it with 2C.
2. The charge on the plates of a capacitor is 6 mC when the potential between them is 2.4 kV. Determine the capacitance of the capacitor.
3. For how long must a charging current of 2A be fed to a 5F capacitor to raise the potential difference between its plates by 500 V (Hint: I=Q/t).
4. A direct current of 10A flows into a previously uncharged 5μF capacitor for 1 mS. Determine the potential difference between the plates (Hint: I=Q/t).

Assignment 4

Given below are different types of capacitor. Read about their specifications on the Internet.

List the following parameters of capacitors.

- Operating temperature
- Maximum operating voltage
- Maximum capacitance storage
- Supply type

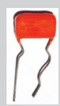
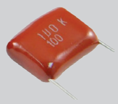
Capacitor image and name			
Ceramic capacitor		Axial electrolytic capacitor	
Radial electrolytic capacitor		Paper capacitor	
Surface mount resistor		Polyester capacitor	

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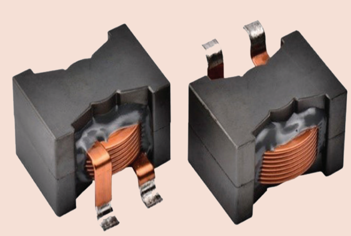
Fig. 2.20 Inductor

Inductor

The word 'inductor' defines induction. Induction is the process or action of bringing about rise. In Inductor, this rise takes place in the form of energy. Inductor is constructed when a conductor material is wound on a magnetic material. Inductor is like a coil as shown in Fig. 2.20. When current flows through the coil, a magnetic field appears around the wire. This way, we can say that an inductor stores energy in the form of magnetic field along the coil. If the current flowing through an inductor changes, a changing magnetic field appears across the wire. This changing magnetic field induces a voltage across the two ends of the wire(s). Inductor opposes the change in the electric current passing through it. This property of opposition is known as 'inductance'.

Table 2.1: Different type of inductors

Type	Name
	Air gap inductor
	Ferrite core inductor
	SMT inductor

Semiconductor

Semiconductors are material that have electrical conductivity between that of an insulator and a conductor. Silicon and germanium are the semiconductors that are widely used in the electronic industry. Semiconductor material are of two types, i.e., intrinsic and extrinsic.

Intrinsic (pure)

It is the pure form of a semiconductor. The word pure here specifies that this semiconductor does not contain any impurity atom. For example, pure form of silicon contains only the atoms of silicon and no other impurity atom is present. The absence of impurity atom results in less conductivity of the semiconducting material. To improve the conductivity of intrinsic semiconductor, an impurity atom has to be added, which is discussed in extrinsic semiconductor.

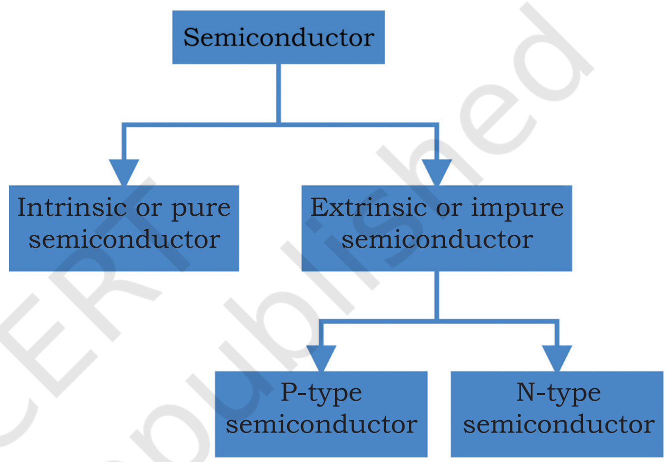


Fig. 2.21 Types of semiconductor

Extrinsic (impure)

When impurity atoms are added to the pure (intrinsic) form of a semiconductor, it is called extrinsic semiconductor. Extrinsic semiconductor is also known as 'impure semiconductor'. Extrinsic semiconductors are classified into N-type and P-type. For example, if there is a presence of impurity atoms [like Arsenic (As)] in the pure form of silicon, it is called 'doping'. Doping increases the conductivity of a semiconductor.

Since the atomic number of silicon is 14, its electronic configuration is 2, 4 and 8. Thus, silicon has four electrons in the outermost shell. In order to increase the conductivity, more free carriers need to be added. As silicon has four electrons in its outermost shell, it is better to add an impurity atom having valence (number of atoms in the outermost shell) either five (penta) or three (tri). The atoms that have five electrons in their

outermost shell are known as pentavalent. The atoms that have three electrons in their outermost shell are known as trivalent.

- When pentavalent impurity atom is added, an extrinsic semiconductor is formed, which is known as N-type semiconductor.
- When trivalent impurity atom is added, an extrinsic semiconductor is formed which is known as P-type semiconductor.

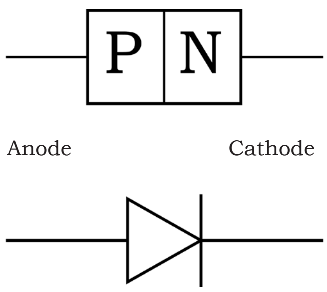


Fig. 2.22 Diode symbol

Diode

Two semiconductors, i.e., P-type and N-type are combined to form a new component, which is known as diode. 'Di' defines two. Thus, a diode has two terminals — anode and cathode as shown in Figs. 2.22 and 2.23.

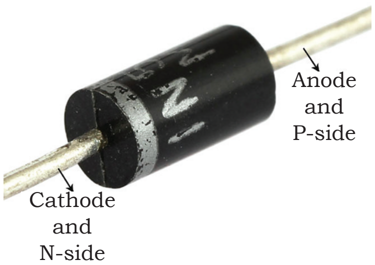


Fig. 2.23 Diode

A diode can be used for switching applications on and off. A diode passes current only in one direction. The P-side is called anode and N-side cathode. When the anode and cathode of a PN-junction diode are connected to external voltage sources such that the positive end of a battery is connected to the anode and negative to the cathode, the diode is said to be in a forward bias condition or we can say that it will act as a closed switch (it will turn 'ON'). In a forward bias condition, the diode will pass the current through it.

Fig. 2.24 Silver ring in diode

When the P-side of the diode is connected to the negative terminal of the battery and N-side to the positive terminal, the diode is said to be in reverse bias condition or we can say that it will act as an open switch (it will turn 'OFF'). In reverse bias condition, the diode will not pass the current through it.

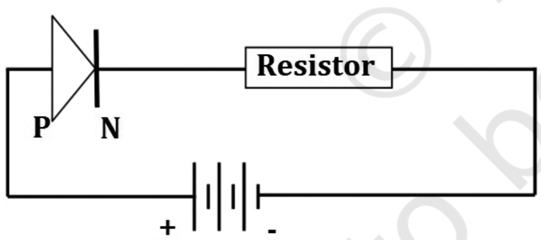


Fig. 2.25 Current will flow in this circuit as diode is in forward bias condition

When the anode of diode is connected to the positive terminal and cathode to the negative of the battery, then the diode is said to be in forward bias condition. In this state, current flows through the diode.

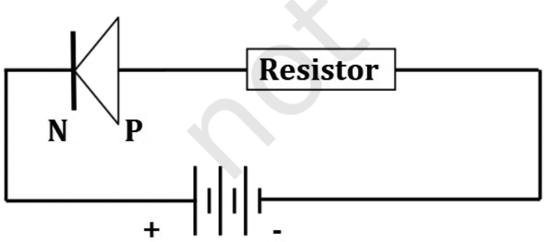


Fig. 2.26 Current will not flow in this circuit as diode is in reverse bias condition

When the anode diode is connected to the negative terminal and cathode to the positive of the battery, then the diode is said to be in reverse bias condition. In this state, current does not flow through the diode.

Transistor

Transistor is a three-layer semiconductor device. Transistors can be of two types — bipolar junction transistor (BJT) and field effect transistor (FET). BJT has three layers, i.e., emitter, base and collector. The point where the two layers touch each other is called 'junction'. The junction where the emitter and base layers touch each other is called 'emitter base junction'. The junction where collector and base layers touch each other is called 'collector base junction'.

The transistor acts as a switch or can be used for amplification.

To understand the functioning of a transistor, we can relate it with the water supply system in our houses. The storage tank, which is kept on the roof of a building, is similar to the emitter in the transistor, which acts as a source of charge carrier (i.e., electrons and holes in semiconductor). The tap on the ground is similar to the base of the transistor. This tap controls the flow of water. Likewise, the base controls the flow of charge carrier. The bucket on the ground collects the water coming from the storage tank. Likewise, the collector of the transistor collects the charge carriers coming from the emitter (Fig. 2.27). Therefore, there are two junctions in the transistor, i.e., emitter and collector based junctions.

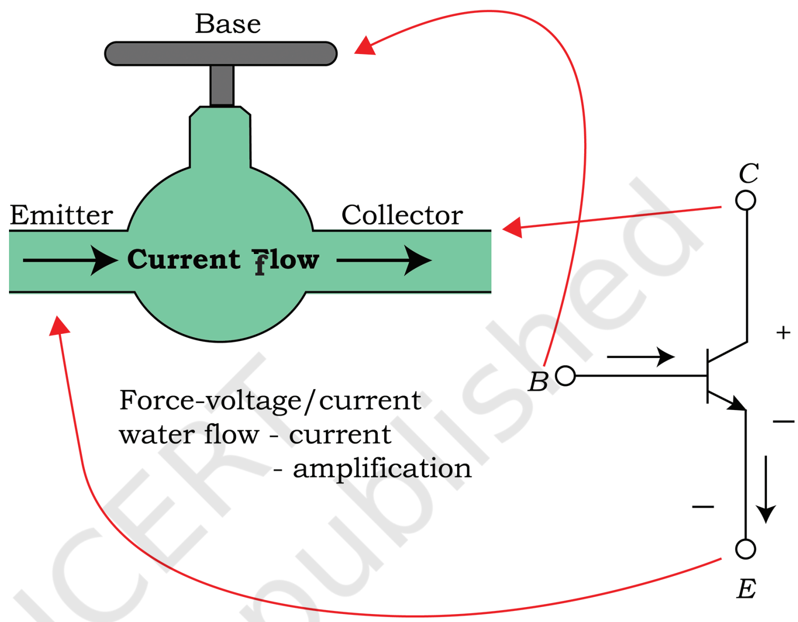


Fig. 2.27 Analogy of transistor

Identifying BJT terminals

Keep the transistor in such a way that the flat surface faces towards you as shown in Figs. 2.28(a) and (b).

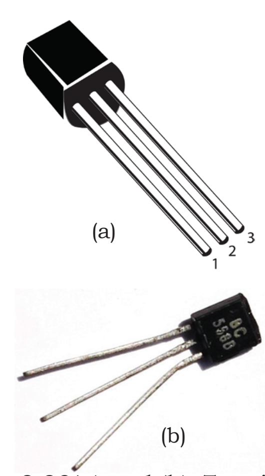


Fig. 2.28(a) and (b): Terminals of a transistor

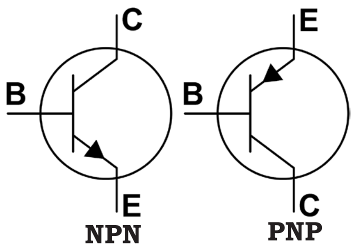


Fig. 2.29 BJT symbol

The bipolar junction transistor (BJT) has three terminals (Fig. 2.29).

1. Emitter (E)
2. Base (B)
3. Collector(C)

The schematic symbol of the BJT is given in Fig. 2.27.

Identifying BJT terminal using multimeter

NPN and PNP are the two types of BJT. Both are similar in physical appearance, and hence, cannot be differentiated. A multimeter is used to identify the type of BJT.

The following points illustrate the steps to identify BJT types.

- If we see a transistor internally, BJT has two junctions (NPN ≡ N - P - N ≡ NP junction + PN junction and PNP ≡ P - N - P ≡ PN junction + NP junction).
- Emitter to base is one PN junction (diode) and base to collector is another PN junction (diode) as shown in Fig. 2.30.

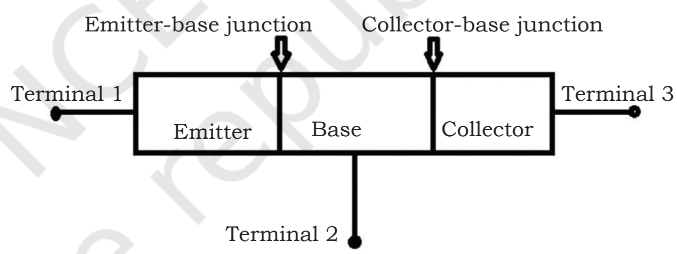


Fig. 2.30 Emitter-base and collector-base junctions

- When a multimeter is set in the diode mode, it will show the voltage. If we keep the positive probe of the multimeter on to the anode of the diode and negative probe on to the cathode, then the multimeter will show forward voltage drop of diode.

Fig. 2.31 Diode in forward bias condition

- When the multimeter is set in the diode mode, it will not show the voltage. If we keep the positive probe of the multimeter on to the anode of the diode and negative probe on to the cathode, then the multimeter will not show any voltage.

Fig. 2.32 Diode in reverse bias condition

Practical Exercise 3

Identification of NPN-type transistor

Material required

Multimeter, transistor and connecting cords

Procedure

1. Connect the red cord to the voltage measuring point (Fig. 1).

Fig. 1

2. Connect the black cord to the common point (Fig. 2).

Fig. 2

Notes

3. Turn the multimeter in the diode mode (Fig. 3).

Fig. 3

4. Touch the red probe to the centre pin (base) of the transistor, black probe to either of the two — pin 1 (emitter) or pin 3 (collector) of BJT (Fig. 4).

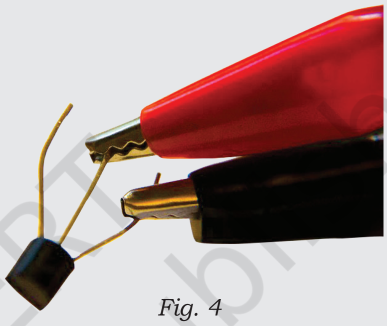


Fig. 4

5. Look at the display on the multimeter.
6. It will be NPN transistor. The logic behind this is, in NPN transistor
   - Emitter (E) – N-type material – Equivalent to cathode of the diode
   - Base (B) – P-type material – Equivalent to anode of the diode
   - Collector (C) – N-type material – Equivalent to cathode of the diode
7. If the multimeter positive probe is connected to the anode and negative probe to the cathode, then it will show the voltage. If the connections are interchanged, it will not show any value (Fig. 5).

Fig. 5

Practical Exercise 4

Identification of PNP-type transistor

1. Connect the red cord to the voltage measuring point (Fig. 1).

Fig. 1

2. Connect the black cord to the common point (Fig. 2).

Fig. 2

3. Turn the multimeter in the diode mode (Fig. 3).

Fig. 3

4. Touch the black probe to the centre pin (base) of the transistor, red probe to either of the two — pin 1 (emitter) or pin 3 (collector) of BJT (Fig. 4).

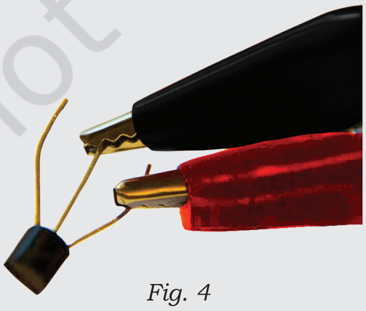


Fig. 4

Know more...

Switch is a device, which has two operations, i.e., ON and OFF. When a switch is closed (ON), current flows in the circuit. In this case, the circuit is said to be complete. When a switch is open (OFF), current does not flow in the circuit. In this case, the circuit is said to be incomplete.

Amplification is the process of increasing the level of voltage and current. A transistor is used in such a way that it increases the voltage and current level of the input signal. Transistors have three terminals. In transistors, the major current flows between any two terminals, while the third terminal is used for controlling the flow of current between the terminals.

Notes

5. Look at the display of the multimeter.
6. It will be a PNP transistor.
   - Emitter (E) – P-type material – Equivalent to anode of the diode
   - Base (B) – N-type material – Equivalent to cathode of the diode
   - Collector (C) – P-type material – Equivalent to anode of the diode
7. If the multimeter positive probe is connected to the anode and negative probe to the cathode, then it will show the voltage. If the connections are interchanged, it will not show any value (Fig. 5).

Fig. 5

Transformer

A transformer is a static unit. It simply transforms the voltage level of an AC signal. It either steps up or steps down the AC voltage. It works on the principle of electromagnetic induction. A transformer does not change the frequency of applied signal. Transformers play an important role in electrical systems (Figs. 2.33 and 2.34).

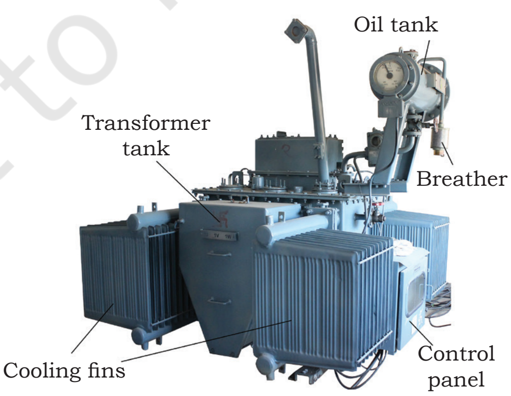


Fig. 2.33 Parts of a transformer

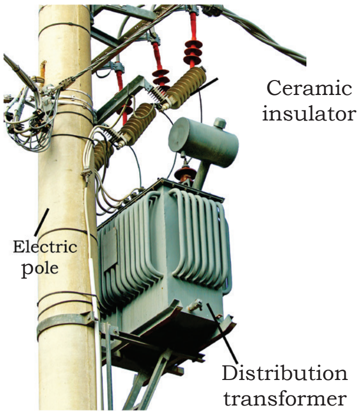


Fig. 2.34 Distribution transformer mounted on a pole

1. Transformers are available in a number of sizes, for example, the transformer used in a mobile charger is very small, whereas, those used in an electricity board substation are bulky or big.
2. High voltage is used for transmission in substations and low voltage in offices and homes.
3. Transformers are used to increase or decrease the AC voltage in transmission and distribution of electricity.
4. The basic construction of a transformer includes two coils wound on the magnetic frame or core.
5. Both the coils are magnetically coupled, whereas, they are electrically insulated from each other.
6. The primary or input coil is connected to the energy source, while secondary or output coil supplies power to load.
7. Electromagnetic induction is used in transformers. In power grids, large transformers are used. These transformers are used for the generation, distribution and transmission of energy (Fig. 2.35).

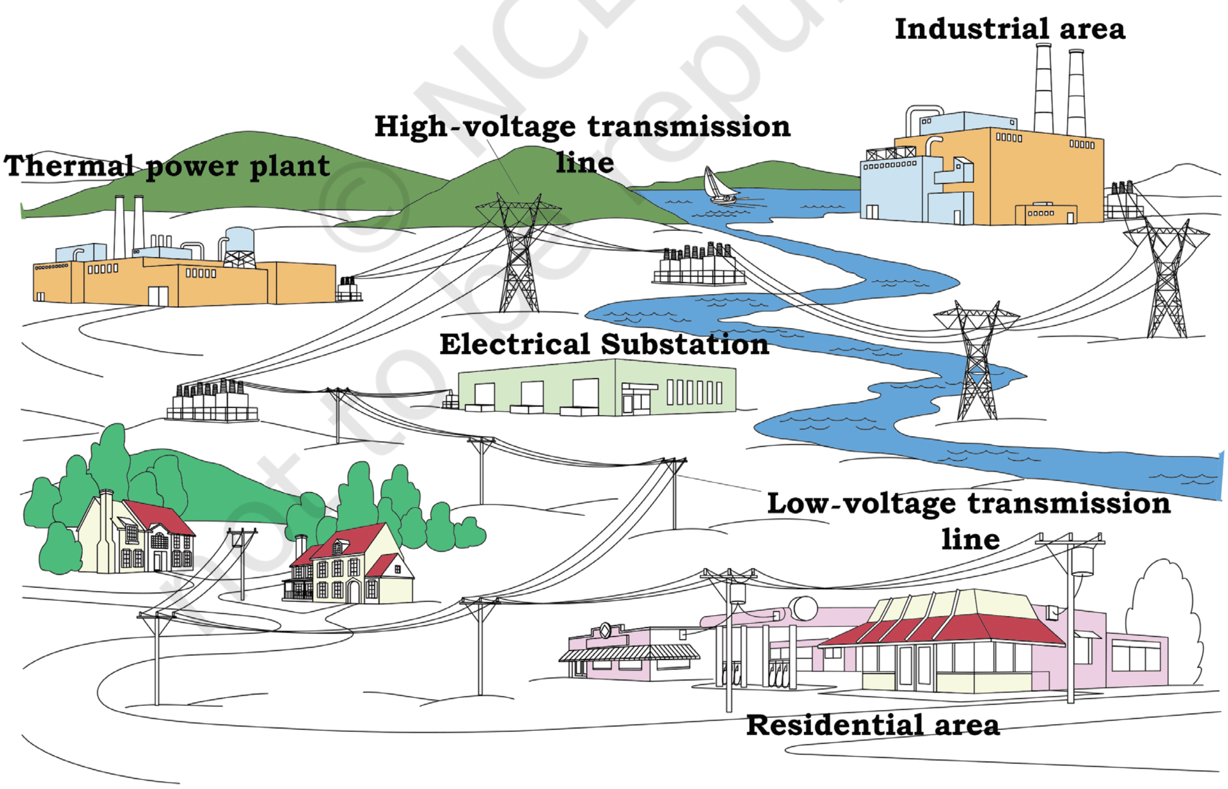
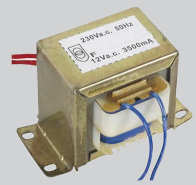
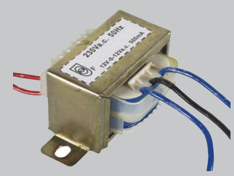


Fig. 2.35 Electrical network

NOTES

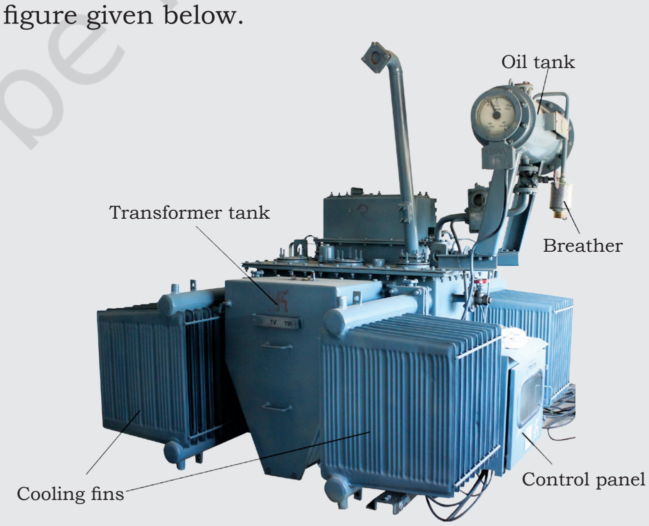
Assignment 5

Given below are different type of transformers. Read about the specifications of these transformers on the Internet and fill in the table given below.

Transformer	Name of transformer	Specification mentioned on the transformer
	Simple step down transformer	Input voltage: Output voltage: Operating frequency:
	Centre tape transformer	Input voltage: Output voltage: Operating frequency:
	High frequency transformer	Input voltage: Output voltage: Operating frequency:

Assignment 6

Visit your nearest power distributing substation. Identify and name the different parts of a high-voltage transformer as shown in the figure given below.



Practical Exercise 5

Perform an experiment to identify the primary and secondary winding of a transformer.

Material required

Transformer (220V to 12V), multimeter, input supply, 200-watt bulb, wire, wire stripper, wire cutter, insulation tape

Procedure

1. Connect a wire to the primary winding of the transformer.
2. Connect a wire to the secondary winding of the transformer.
3. Connect the primary winding wire to the input supply carefully.
4. Connect the secondary winding wire to the load.
5. Turn on the power supply.
6. Measure the voltage using a multimeter at the primary and secondary winding.
7. Note the reading displayed on the screen of the multimeter.

Integrated Circuit (IC)

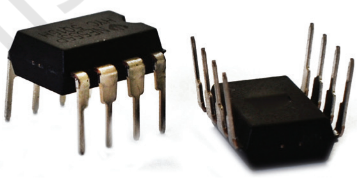


Fig. 2.36 Integrated Circuit

An integrated circuit is a combination of electronic components on a single piece (or chip) of semiconductor material as shown in Fig. 2.36. An integrated circuit has a large number of tiny transistors that are fit in a small chip to make circuits, which are smaller, cheaper and faster.

An integrated circuit has a number of pins. Each pin defines an input or output. A data sheet is required when working with an integrated circuit chip. It gives complete information about a particular integrated circuit. The internal structure of an IC is shown in Fig. 2.37.

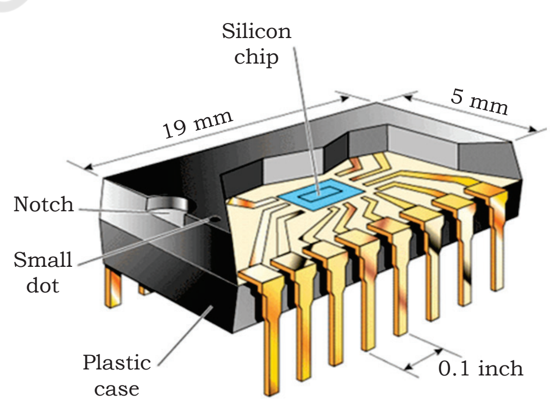


Fig. 2.37 Internal structure of IC

Light Emitting Diode

Light Emitting Diodes (LEDs) comprise several layers of semiconducting material. When the diode is utilised with DC, the active layer produces light. The LED emits light in a particular colour and

this colour is dependent on the type of semiconductor material used in it. LEDs are made of semiconductor crystals as shown in Fig. 2.38.

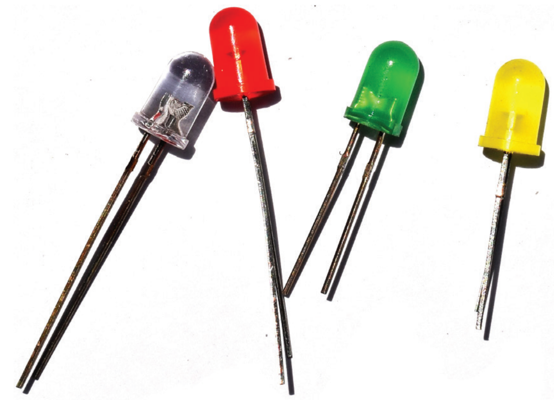


Fig. 2.38 Light Emitting Diode

When current flows through them, they emit red, green, yellow or blue light, depending on the composition of the crystal compounds.

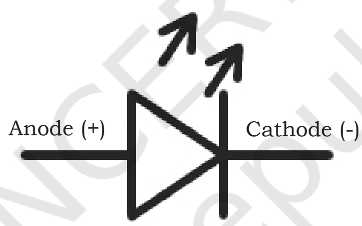


Fig. 2.39 LED symbol

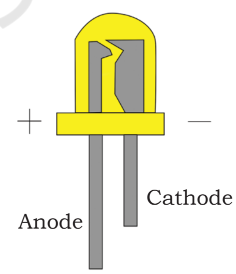
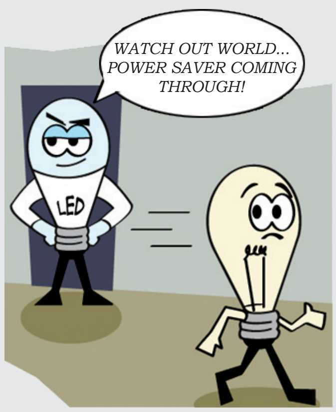


Fig. 2.40 LED light



Know more...

Why LEDs are a good choice?

1. Durable
2. High efficiency
3. Low energy use
4. Compact size
5. No UV issue

Check Your Progress

A. Multiple choice questions

1. A diode ______________________________.
   (a) is the simplest of semiconductor devices
   (b) has characteristics that closely match those of a simple switch.
   (c) is a two-terminal device
   (d) All of the above

2. Which of the following is a semiconductor material?
   (a) Silicon
   (b) Germanium
   (c) Both (a) and B
   (d) None of the above

NOTES

3. An LED emits light when it is connected in __________.
   (a) forward biased
   (b) reverse biased
   (c) unbiased
   (d) None of the above
4. Which of the following is a two-terminal semiconductor device?
   (a) Diode
   (b) Triode
   (c) Transistor
   (d) Integrated Circuit
5. Resistance of variable resistors can be changed, and hence, they are called _________________.
   (a) rheostat
   (b) fixed resistor
   (c) variable resistor
   (d) None of the above
6. ____________ consists of a coil or wire loop.
   (a) Inductor
   (b) Capacitor
   (c) Resistor
   (d) Diode
7. A three-terminal semiconductor device is ________.
   (a) diode
   (b) transistor
   (c) IC
   (d) All of the above
8. Different colours emitted by an LED is because of _________________.
   (a) applied voltage
   (b) forward or reverse bias
   (c) different compound formation
   (d) Power supply
9. An LED requires ____________ supply.
   (a) AC
   (b) DC
   (c) AC or DC
   (d) Non-linear supply
10. Transformer is used to ______________.
    (a) step up the voltage
    (b) step down the voltage
    (c) Both (a) and (b)
    (d) Non-linear supply
11. A transformer works on __________________.
    (a) AC
    (b) DC
    (c) Both AC and DC
    (d) None of the above

NOTES

12. A transistor has ____________ layers and ____________ junctions.
    (a) two, three
    (b) three, two
    (c) three, three
    (d) two, two
13. A diode is in forward bias condition when ___________.
    (a) cathode is connected to the positive and anode to negative terminal of a battery
    (b) cathode is connected to the negative and anode to positive terminal of a battery
    (c) no specific polarity is required
    (d) None of the above
14. A diode is in reverse bias condition when ___________.
    (a) cathode is connected to the positive and anode is connected to negative terminal of a battery
    (b) cathode is connected to the negative and anode to positive terminal of a battery
    (c) no specific polarity is required
    (d) None of the above
15. Devices that store energy in the form of electric field are called ________________.
    (a) capacitors
    (b) inductors
    (c) resistors
    (d) diodes
16. Devices that store energy in the form of a magnetic field are called _______________.
    (a) capacitors
    (b) inductors
    (c) resistors
    (d) diodes
17. Resistance of a material affects the ________________.
    (a) length
    (b) temperature
    (c) thickness
    (d) All of the above
18. Pentavalent impurities in extrinsic semiconductor have _________ electrons in their outermost orbit.
    (a) 3
    (b) 5
    (c) 4
    (d) 2
19. Trivalent impurities in extrinsic semiconductor have __________ electrons in their outermost orbit.
    (a) 3
    (b) 5
    (c) 4
    (d) 2

20. The pure form of semiconductor is called ____________________.
    (a) intrinsic semiconductor
    (b) extrinsic semiconductor
    (c) Both (a) and (b)
    (d) None of the above
21. The impure form of semiconductor is called ________________.
    (a) intrinsic semiconductor
    (b) extrinsic semiconductor
    (c) Both (a) and (b)
    (d) None of the above
22. What are the two major categories for resistors?
    (a) Low and high power value
    (b) Commercial and industrial
    (c) Low and high ohmic value
    (d) Linear and non-linear
23. Carbon composition resistors are made of __________________.
    (a) germanium and lead
    (b) silicon and germanium
    (c) carbon and silica
    (d) lead and carbon
24. Which of the following is true for resistance?
    (a) Symbolised by R, measured in Ohm and directly proportional to conductance
    (b) Represented by the flow of fluid in the fluid circuit
    (c) Directly proportional to current and voltage
    (d) The opposition to current flow is accompanied by dissipation of heat
25. Carbon composition resistors are available in _______________ power rating.
    (a) 1/4 watt
    (b) 1/2 watt
    (c) 1 watt
    (d) All of the above
26. For fixed voltage, if resistance decreases, then current will ________________.
    (a) decrease
    (b) double
    (c) increase
    (d) remain the same
27. Resistance in a circuit is ________________.
    (a) the same as current
    (b) in opposition to current
    (c) the same as voltage
    (d) in opposition to voltage

Notes

NOTES

28. Which of the following is not a film resistor?
    (a) Carbon film resistor
    (b) Metal film resistor
    (c) Thin film resistor
    (d) Thick resistor
29. Which of the following is the temperature operating range of cracked carbon resistor?
    (a) 700–800 degree Celsius
    (b) 900–1000 degree Celsius
    (c) 500–600 degree Celsius
    (d) 600–700 degree Celsius
30. Which of the following is not a non-linear resistor?
    (a) Thermistor
    (b) Varistor
    (c) Photoresistor
    (d) Carbon film resistor
31. Which of the following is not a linear resistor?
    (a) Potentiometer
    (b) Trimmer
    (c) Wire wound resistor
    (d) Photoresistor

B. Fill in the blanks

1. Transformers work on _______________ voltage.
2. Extrinsic semiconductor is ____________ form of semiconductor.
3. Intrinsic semiconductor is _______________ form of semiconductor.
4. Capacitor stores energy in the form of ___________ field.
5. Inductor stores energy in the form of _____________ field.
6. Diode has _______________ terminals.
7. Silicon is _____________ material.
8. Transistor has ______________ terminals.
9. When LED is in forward bias condition, it will turn _______________.
10. A three-terminal semiconductor device is __________.

C. State whether the following statements are True or False

1. Transformers are used only to step-up the voltage.
2. An LED emits light in a particular colour and this colour is dependent on the type of semiconductor material used in it.

3. A transistor is used as an amplifier and switch.
4. The electromagnetism in a transformer is the energy source for the transformer.
5. Low voltage is used for transmission and high voltage in office and home.
6. Transformer changes the frequency of applied signal.
7. The junction, where the emitter and base layer touch each other, is called emitter-base junction.
8. Amplification is the process of increasing the level of voltage and current.
9. The base unit of capacitance is Farad.
10. Trimmer is a miniature adjustable resistor.
11. Potentiometer is a variable resistor. Its resistance value can be changed using a rotating knob.
12. Negative and positive temperature coefficient are linear resistors.
13. When light is illuminated on a photo resistor, its resistance value decreases.
14. In non-linear resistors, current is directly proportional to the applied voltage.
15. In linear resistors, current is not directly proportional to the applied voltage.
16. In thick film resistors, resistive film is formed on the substrate of silicon to produce high resistance value resistor.
17. In film resistors, resistance value depends on the thickness of ceramic rod placed in it.
18. Linear resistors can be classified into fixed and variable.
19. Variable resistor includes carbon composition resistor, film resistor, wire wound resistor and cracked carbon resistor.
20. LDR stands for light dissipate resistor.

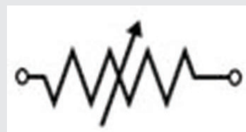
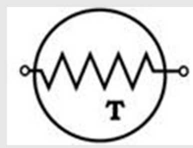
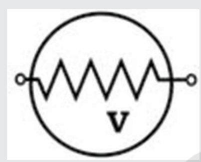
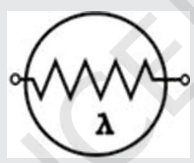
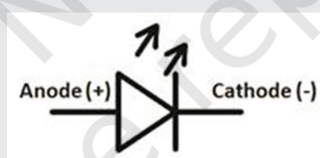
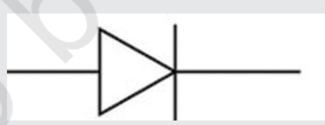
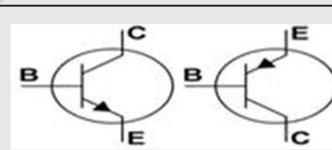
D. Short answer questions

1. Write short notes on— Diode, Transistor, LED, Capacitor, Inductor.
2. What is an extrinsic semiconductor?
3. What is an intrinsic semiconductor?
4. What are the applications of a transistor?
5. Write down the specifications of a capacitor.
6. What is inductance?

NOTES

NOTES

E. Identify the symbols in the table given below

1. 	
2. 	
3. 	
4. 	
5. 	
6. 	
7. 	
8. 	

F. Calculate the value for the following

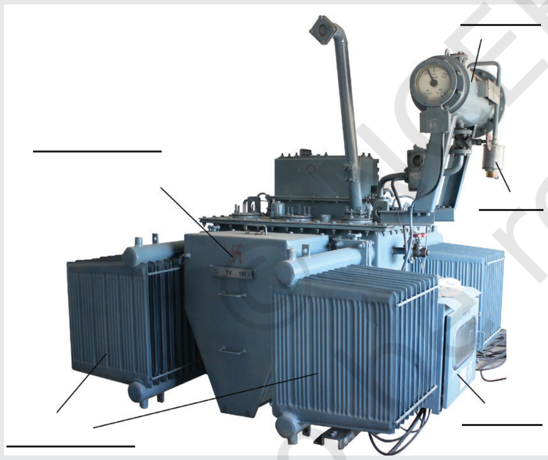
1. A 3-ohm resistor is connected to 12V battery. Determine the current in the circuit.
2. Calculate the capacitance value, when the amount of charge is 2C and 6V is applied across the capacitor.

Notes

3. In an electric circuit, 10V is applied and current in the circuit is 2A. Calculate the value of resistor to be used.
4. Calculate the amount of charge when 220V is applied in a 2.5-microfarad capacitor.
5. Calculate the power consumed by the circuit when voltage and current are 220V and 0.8A, respectively.
6. Calculate the power consumed by a circuit when the applied voltage is 220V and resistance is 10 ohm.
7. Calculate the current in a circuit when power is 200W and resistance is 2 ohm.
8. Calculate the applied voltage when 880C charge is stored in a 4-farad capacitor.
9. What will be the amount of charge, when 440V is applied in a 2-farad capacitor?
10. Calculate the applied voltage, when the power consumed by a circuit is 20W and it has a resistance value of 20 ohm.

G. Label the following figures

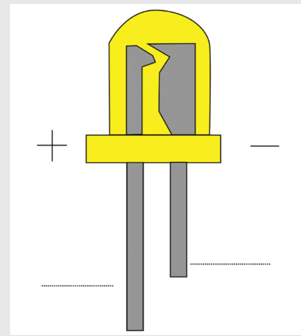
1. Identify and name the parts of a transformer in the figure given below.



2. Identify and name the P-type and N-type terminal of the diode in the figure given below. Also, specify the anode and cathode terminals of the diode.

NOTES

3. Identify the parts of an LED in the figure given below.



4. Identify and name the different types of inductor listed in the following table.

Types	Name
(i) 	
(ii) Ferrite core 	
(iii) 	

H. Match the columns

A	B
(i) Semiconductor	(a) Magnetic field
(ii) Capacitor	(b) Opposition in the flow of current
(iii) Resistor	(c) Unidirectional device
(iv) Inductor	(d) Electric field
(v) Diode	(e) Three-terminal device
(vi) Transistor	(f) Trivalent and pentavalent